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THE VETERINARY JOURNAL

A MONTHLY REVIEW OF VETERINARY SCIENCE

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THE VETERINARY JOURNAL

EDITORS: T. DALLING, *M.A., M.R.C.V.S.* J. McCUNN, *M.R.C.V.S., L.R.C.P.*

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EDITORIAL

ARTIFICIAL INSEMINATION

ARTIFICIAL INSEMINATION, as a means of breeding cattle, is now practised to an increasing extent in this country: the number of centres and sub-centres is gradually extending and in the not distant future there should be a service for all breeders of dairy cattle at least, for those who desire to use it. The Ministry of Agriculture have recently issued an official statement on the extension of artificial insemination in dairy herds for the purpose of increasing the number of calves to be reared for beef purposes. The scheme includes the keeping at centres of beef bulls of breeds which will "colour mark" the calves. It is not intended that this scheme should interfere in any way with the improvement of dairy cattle which is one of the objects of the encouragement of artificial insemination: it is to be confined to the breeding of calves from dairy cows which are unsuited to produce dairy replacements. The breeds of bulls to be used are Hereford, Aberdeen Angus and Galloway, and the service will be free. The scheme came into operation on October 1, and although some time must elapse before it will be in full swing it is hoped to develop on as wide a scale and at as early a date as possible.

With the extension of artificial insemination at the present rate it is essential that still further attention must be given to the health of the semen-producing bulls. There must be no tendency to be any less severe in the tests which are now applied: the health standard which is now demanded in this country must be maintained and, if necessary, raised to a higher level. We read of bulls from the semen of which well over 1,000 cows have been inseminated in a year and the average number of inseminations from groups of bulls appears to be between 500 and 600. It is obvious how much damage could follow the use of semen from bulls capable of transmitting any of the infectious diseases associated with breeding if there was any relaxation in the standard of the examination and testing of the animals. In this connection we draw our readers' attention to the article by Bendixen and Blom which we have pleasure in publishing in this issue of the VETERINARY JOURNAL. It seems clear from the experiences of these observers that we must give more attention to the possibility of bulls being infected by *Br. abortus* and that the tests to be applied for the detection of the infection

may have to be modified. The spread of infection by bulls, themselves shown to be infected, receives attention in the article: the observations on the location of the infection in the genital organs and the results of the agglutination tests, using blood and semen, are of the greatest interest and practical importance.

We have certainly progressed far in our understanding of the handling of semen, thanks to the early pioneers in this work both in our own and other countries: their work has made artificial insemination a practical proposition. Some of the features of bull fertility, especially concerned with animals used for this work, are now beginning to be understood: there is, however, much more to learn and it is essential that the resources of the various branches of science be sought and applied in our search for knowledge. Work in the laboratories together with examination of results in the field must go on simultaneously: with the extensive use of artificial insemination the time is ripe for intensive studies of the problems of bull fertility. In addition, although the fertility of the male is all-important and of the greatest economic importance, fertility in the female must also receive attention. Here again our knowledge has improved but there remain very wide gaps which have still to be filled in and which demand the careful and time-consuming activities of the laboratory worker and the veterinarian in the field.

GENERAL ARTICLES

INVESTIGATIONS ON BRUCELLOSIS IN THE BOVINE MALE, WITH SPECIAL REGARD TO SPREAD OF THE DISEASE BY ARTIFICIAL INSEMINATION*

By H. C. BENDIXEN and ERIK BLOM

From the Royal Veterinary and Agricultural College, Copenhagen, Department of Special Pathology and Therapy (Chief: Professor H. C. Bendixen).

In 1942 a case of acute brucellar ampullitis was demonstrated in a bull (1944a) that was being used for artificial insemination. It was shown that at a certain stage the use of this bull had caused positive blood agglutination reactions for brucella infection in about 71 per cent. of inseminated cows in hitherto brucellosis-free herds (1944b). Since that observation, particular attention has been paid to this possibility.

When, subsequently, a similar striking instance of this form of spreading brucellar infection was found, collaboration was established between the Danish State Veterinary Directorate and the Laboratory for Special Pathology and Therapy of the Royal Veterinary and Agricultural College, especially for a more thorough examination of the bulls employed for artificial insemination. Efforts have been made by the Veterinary Directorate to induce the owners of such bulls —and in most cases this means the cattle-breeding associations founded for this purpose—voluntarily to allow the bulls to be examined at certain intervals, following the publication of rules in two announcements issued by the Veterinary Directorate in 1944. Such examinations have been made in the laboratory since December 15, 1944, and this paper represents an account of the results obtained up to December 31, 1946. During this two-year period, a total of 1,109 specimens of semen and 552 blood samples from 394 bulls have been examined.

The blood samples were examined for their content of Brucella agglutinin.

The specimens of semen (sent to the laboratory in thermos bottles with crushed ice) have been submitted to the following forms of examination: (1) macroscopic examination; (2) catalase test (1947); (3) microscopy of stained smears; (4) agglutination test of the sperm plasma with Brucella antigen; (5) cultivation on serum agar plates (with addition of gentian violet in the proportion 1 in 100,000) for demonstration of any possible presence of Brucella bacteria; (6) inoculation of guinea-pigs.

The veterinary surgeons who sent the specimens of semen to the laboratory reported at the same time the result of their clinical examination of the genitals of the respective bull. Of the Brucella-infected bulls with pathological changes in the semen, 18 were admitted to the Medical Clinic of the College for more thorough examination before they were slaughtered.

An analysis of this material shows that of the total 394 bulls, 331 (84 per cent.) were normal in that they showed no blood reaction, no pathological substances in the semen, and no clinical alterations of the organs. Of the remaining bulls, 58 (14.7 per cent.) showed a positive reaction in the blood serum;

* Paper read in Section II of the IV International Congress for Microbiology, Copenhagen, 1947.

30 of them also showed positive agglutinin reaction of sperm plasma to Brucella antigen; and in 15 the presence of Brucella bacteria in the semen was demonstrated by cultivation or by inoculation of guinea-pigs.

Of the Brucella-positive bulls, 36 belonged to "bull centres," i.e., "dispensaries" from which semen from one or several bulls was distributed regularly for artificial insemination purposes. The present examination concerns bulls from 62 of the total 115 "centres" in this country.

Of the reacting bulls, 22 belonged to owners who had used them chiefly for natural service.

In five bulls (1.3 per cent.) with pathological changes in the semen in the form of admixture of blood or exudate the cause of the morbid condition could not be ascertained, but undoubtedly it was not of brucellar origin, so this group represents the occurrence of inflammatory conditions that may still be encountered even though brucellosis were completely eradicated.

The 58 brucellar bulls fall naturally into two groups—namely, 28 (48.3 per cent.) which showed only a positive agglutination reaction in the blood (Table I, B-reactors), and 30 (51.7 per cent.) which showed in addition the presence of agglutinins in the sperm plasma (Table II, A-reactors).

TABLE I.

SCHEMATIC SURVEY OF 28 BULLS WHICH SHOWED A POSITIVE AGGLUTINATION REACTION IN BLOOD SERUM ALONE (B-REACTORS).

Most of the agglutination titres obtained were low, and at the last examination 16 of the bulls showed again a negative reaction.

Record No. of the bull	Approximate age of bull at time of +reaction (in years)	First +test Titre	First +test Date	Last +test Titre	Last +test Date	Reaction-free on date	Remarks
B 1678	10	1 : 10	10/ 1/46	1 : 10	6/ 3/46		Killed
B 1684	10	1 : 40	16/ 1/46	1 : 40	26/ 4/46		Killed
B 1072	9	1 : 10	13/ 9/45	1 : 200	11/ 4/46		Sold
B 2086	9	1 : 10	26/ 9/46	1 : 10	24/ 1/47		
B 1032	7	1 : 20	28/ 9/46			15/11/46	
B 1101	7	1 : 40	25/ 1/45	1 : 40	26/ 2/45		Killed
B 1030	6	1 : 10	19/ 4/45	1 : 20	13/ 6/46		Sold
B 1701	6	1 : 40	29/ 1/46	1 : 40	5/ 7/46		Sold
B 1073	5	1 : 10	18/ 1/45				No later test
B 1681	5	1 : 40	10/ 1/46			21/ 4/47	
B 2203	5	1 : 10	18/10/46	1 : 10	26/ 7/47		
B 2064	4	1 : 160	6/ 9/46				Killed, no autopsy
B 1002	4	1 : 10	17/10/46			18/11/46	
B 1467	4	1 : 10	1/ 5/46			22/ 6/46	
B 1005	4	1 : 10	24/ 3/45			6/ 4/45	
B 1011	3	1 : 10	24/12/44			26/ 9/46	
B 1398	3	1 : 10	6/ 9/45			20/10/45	
B 1300	3	1 : 10	12/ 9/46			18/ 1/47	
B 2221	3	1 : 10	30/10/46			28/ 2/47	
B 2005	3	1 : 10	29/ 7/46			29/ 1/47	
B 1182	3	1 : 10	28/ 9/46			14/10/46	
B 1082	3	1 : 10	16/ 2/46			12/10/46	
B 1364	2	1 : 10	22/ 2/46			5/ 6/46	
B 1980	2	1 : 40	29/ 6/46	1 : 10	29/ 3/47		
B 2008	2	1 : 10	29/ 7/46			29/ 1/47	
B 1679	2	1 : 10	11/10/46			15/ 2/47	
B 1508	1	1 : 20	/ 3/45			25/10/45	
B 1947	1	1 : 40	25/ 5/46				

As to the 28 B-reactors (Table I), it has not been possible to demonstrate any clinical changes in their genital organs or abnormal changes in their semen. Concerning their blood titre, 19 showed a titre of 1-10; two, 1-20; six, 1-40; and one, 1-160. Among the 21 bulls with a titre of 1-10 and 1-20, 15 had a negative reaction in from two weeks to 21 months later. Four of the bulls still showed a positive titre of 1-10 or 1-20 at the last examination, while in one bull the titre rose to 1-200—probably on account of a bursitis præcarpea, which had become infected with Brucella bacteria. Two bulls were examined once only. In the bulls with a titre of 1-40 or higher, the titre remained rather constant throughout the observation period—with exception of one bull (B 1681), which became negative.

Among the 30 A-reactors (Table II) which showed a positive titre in the sperm plasma as well as in the blood serum, Brucella bacteria were demonstrated in 15 either in cultures or by guinea-pig inoculation from the specimens of semen received. In two additional bulls whose semen had proved negative by cultivation and by inoculation of guinea-pigs, Brucella bacteria were isolated from the infected organs when the animals were killed.

From Table II it will be seen that the blood titres for these animals varied somewhat, but on the whole they were considerably higher than those for the B-reactors. In relation to the blood titre, the agglutination titre of the sperm plasma showed considerable variation, being often lower, sometimes the same, and in a number of cases higher. This fact is of considerable interest.

The following four organs have been found infected: the seminal vesicle, the ampulla of the ductus deferens, the testis and the epididymis. In none of the animals examined *post-mortem* was the lesion found localised to the prostate or to the bulbo-urethral gland.

A typical feature was that after the acute stage of Brucellar *vesiculitis* had passed the agglutinative titre of the sperm plasma was relatively high, while that of the blood was lower.

Table III illustrates a typical case of this kind, where the blood titre was constantly about 1-40, while the titre of the sperm plasma varied from 1-100 to 1-1280.

TABLE III

BULL A 1908. CASE OF UNILATERAL BRUCELLAR VESICULITIS.

Note the relatively low titre in blood serum, while the agglutination titre of the sperm plasma is at a considerably higher level.

Date	Blood titre	Sperm plasma titre	Macroscopic appearance	Microscopy of smears	Catalase value	Brucella bact. demonstrated in culture	guin.-p.
18/4/46	1 : 50	1 : 100	slight reddish tint		800	0	+
1/6	1 : 40	1 : 640	floccules of pus	++	1100	0	+
25/6	1 : 40	1 : 320	normal	++	1200	0	-
2/7	1 : 40	1 : 320	floccules of pus	++	>2000	0	0
17/7	1 : 40	1 : 640	+ pus	++	1600	0	+
1/8	1 : 40	1 : 1280	normal	++	1400	0	0
16/8	1 : 40	1 : 640	„	+	420	0	0
23/9			„	++	400	0	0
7/10	1 : 40	1 : 640	„	+	260	0	0

TABLE

SCHEMATIC SURVEY OF 30 BULLS WITH POSITIVE AGGLUTINATION REACTION IN

Record No. of the bull	Age of bull at time of + reaction (in years)	Blood serum reaction		Examinations		
		Titre	Date	Macroscopic changes	Microscopy of smears*	Catalase value
A 1802	7	1 : 10	4/11/46	large lumps of pus	++	1200
A 1099	6	1 : 20	25/1/45	none	0	60
A 1291	6	1 : 10	6/6/45	very lumpy	+++	>2000
A 1087	5	? (hemolytic)		none	0	350
A 1100	5	1 : 10	25/1/45	none	0	100
A 1302	5	1 : 160	5/7/45	few yellowish lumps	++	650
A 2296	5	1 : 1280	30/11/46	mucoid; floccules of pus	+++	1600
A 2219	5	1 : 100	30/10/46	none	0	200
A 2218	4	1 : 320	2/11/46	small lumps of pus	++	620
A 1163	4	1 : 200	15/2/45	none	0	130
A 1261	4	1 : 320	16/2/45	none	++	450
A 1663	3	>1 : 200	Dec., '45	abnormally thin	0	60
A 1102	3	1 : 10	25/1/45	none	0	70
A 2019	3	1 : 160	20/8/46	reddish-brown tint	+	400
A 1662	3	1 : 80	17/4/46	reddish tint	(+ blood)	1000
A 1146	3	1 : 640	10/4/45	abnormally thin	0	100
A 1289	3	1 : 160	15/6/45	faint reddish tint	++	1000
A 2260	3	1 : 200	14/11/46	none	0	160
S.P.	3	1 : 40	17/1/44	lumpy		
A 13	2	1 : 640	5/2/46	abnormally thin	0	130
A 1908	2	1 : 50	10/4/46	tiny floccules of pus	++	1100
A 1262	2	1 : 20	March, '45	none	0	200
A 1308	2	1 : 2560	11/7/45	abnormally thin	0	100
A 1974	2	1 : 100	Jan., '46	reddish tint	+	500
A 1898	2	1 : 20	1/3/46	none	+	540
A 1098	1½	>1 : 200	29/5/43	none	0	100
A 1759	1½	1 : 40	16/2/46	none	+	240
A 1623	1½	>1 : 200	Nov., '45	tiny floccules of pus	+	350
A 2028	1½	>1 : 200	Aug., '46	brownish tint	++	740
A 1919	1½	1 : 20	16/5/46	floccul. sedim.	+++	>2000

* 0: No pus cells observed.
+: Few pus cells observed.
++: Many pus cells observed.
+++: Numerous pus cells observed.

This typical feature may not be apparent, however, when the outlet from the infected seminal vesicle becomes occluded by the inflammatory process, so that its secretion with the admixture of exudate is prevented from flowing out and mixing with the ejaculate. This is plainly evident from the case recorded in Table IV, where the agglutinins in the sperm plasma for a while had disappeared completely, while the sperm at the same time apparently had become of practically normal character, as the admixture of blood and pus had ceased. Subsequently—as is also illustrated by Table IV—the admixture of exudate may again appear in the semen if the evacuation of the seminal vesicle involved is re-established. Cases of bilateral vesiculitis showed protracted and pronounced changes in the macroscopic appearance of the semen with only a slight tendency to return to normal aspect. The highest titre in sperm plasma demonstrated in these examinations was 1-10,000. This was found in a case of bilateral vesiculitis and ampullitis; at the same time the bull showed a blood serum titre of 1-1280.

II

SPERM PLASMA AS WELL AS IN BLOOD SERUM (A-REACTORS)

of semen							
Agglutination Titre	Date	Brucella bact. Cultures †	Guin.-p.	Clinical diagnosis‡	Autopsy diagnosis‡	Brucella bact. demonstr. in organs. Cultures	Guin.-p.
1:10 p	2/11/46	+++	+	Ves. l. + Amp. l.	Ves. l. + Amp. l.	+	+
1:40	5/10/45	0	0	0	still living		
1:20	25/6/45	+++	+	Epid. + Orch. r.	Epid. + Orch. r.	0	+
1:10	22/1/45	0	0	Ves. l.	still living ?		
1:40	7/6/45	0	+	0	Amp. r.	+	+
1:320	5/7/45	0	0	Ves. l.	organs lost		
1:10.000	30/11/46	0	+	Ves. bilat.	Ves. bilat. + Amp. bilat.	+	+
1:40	30/10/46	0	0	Ves. r.	Ves. r.	+	+
1:1280	30/10/46	0	0	Ves. l.	Ves. l.	0	0
1:40	22/2/46	0	0	?	still living		
1:2560	16/5/45	0	0	Ves. bilat.	Ves. bilat.	0	0
1:40	22/12/45	0	0	Orch. r.	no autopsy		
1:40	2/2/45	+	0	0	Amp. l.	+	+
1:200	9/8/46	0	+	Epid. r. ?	still living		
1:10 p	17/4/46	0	0	Ves. l.	Ves. l. + Amp. r.	0	0
1:640	12/2/45	0	0	Orch. r.	Orch. r. + Ves.	0	+
1:160	1/6/45	+	+	Ves. r.	Ves. r.	0	0
1:20	14/11/46	0	+	Ves. r.	still living		
1:40	18/11/44	0	+	Ves. l.	Ves. l.	0	0
1:40	8/2/46	0	0	Epid. r.	Epid. r.	0	0
1:100	18/4/46	0	+	Ves. l.	Ves. l.	0	0
1:40	16/5/45	0	0	0	still living		
1:20	11/7/45	+	0	Orch. r.	Orch. r.	0	0
1:320	21/6/46	0	0	Ves. l.	fate unknown		
1:100	12/4/46	0	+	Ves. l.	Ves. l.	+	+
1:10	25/1/45	0	0	0	fate unknown		
1:40	8/4/46	0	+	Ves. r.	Ves. r. + Amp. r.	0	+
1:80	21/11/45	0	0	Ves. l.	fate unknown		
1:40	14/8/46	+	(+)	Orch. l.	no autopsy		
1:20	16/5/46	0	+	Orch. r. + Ves. bilat.	Orch. r. + Ves. bilat.	+	0

† 0: No growth of Brucella bact. in cultures.
+: 1-10 colonies of Brucella bact. in cultures.
+++: Innumerable colonies, almost forming a coherent membrane.
‡ Ves.—vesiculitis; Amp.—ampullitis; Epid.—epididymitis; Orch.—orchitis; l.—left; r.—right; bilat.—bilateral.

TABLE IV.

BULL A 1289. CHRONIC BRUCELLAR VESICULITIS ON THE RIGHT SIDE.

Note the pronounced variations in the agglutination titre of the sperm plasma. Thus, no agglutination is seen in the two tests on June 19 and 25, when, in addition, the macroscopic appearance, microscopy and catalase value show approximately normal conditions.

Examination of specimens of semen obtained at such a period will not reveal the lesion of the bull, but the presence of vesiculitis will be demonstrable on clinical examination. Subsequently the abnormal changes in the semen reappear.

Date	Blood titre	Sperm plasma titre	Macroscopic appearance	Microscopy of smears	Catalase value	Brucella bact. demonstrated in culture	guin.-p.
1/6/45		1 : 160	slight reddish tint	++	1000	+	+
15/6	1 : 160	1 : 10	reddish tint	(+ blood)	2000	0	0
19/6			normal	0	320	0	0
25/6			"	0	260	0	0
2/7	1 : 160	1 : 100	slight reddish tint + pus	+	1000	0	0
11/7	1 : 160	1 : 40	+ pus	++	>2000	0	+

Ampullitis as a rule also gives rise to a higher sperm plasma titre than blood serum titre. In cases of this kind, however, both titres are relatively low, the sperm plasma titre being often about 1-40, while the blood serum titre is about 1-10. A typical example of this is recorded in Table V. From this it is evident that bulls with such reactions may very well remain bacillary excretors for a long time.

TABLE V

BULL A 1102. CHRONIC BRUCELLAR AMPULLITIS ON THE LEFT SIDE.

Note the low agglutinin content of the blood serum and the slightly higher titre in the sperm plasma. At this chronic stage, as a matter of fact, the semen is essentially of normal character.

In this connection, it is to be mentioned that in the acute stage of ampullitis the semen usually shows distinct macroscopic changes.

Date	Blood titre	Sperm plasma titre	Macroscopic appearance	Microscopy of smears	Catalase value	Brucella bact. demonstrated in culture	guin.-p.
25/1/45	1 : 10						
2/2		1 : 40	normal	0	70	+	0
26/2	1 : 10	1 : 40	„	0	60	0	0
19/6	1 : 10	1 : 10	thin wheyish*	0	80	0	0
7/7		1 : 40	normal		100	+	+
7/9	1 : 10	1 : 40	„	+	300	+	+
6/10		1 : 100	„		200	0	0
19/10	1 : 10						

* On this day the ejaculate was incomplete.

In cases of *epididymitis* the blood serum titre has a tendency to be higher than that of the sperm plasma; and this applies in an even higher degree to cases of *orchitis*. These findings are taken to signify a greater tendency to occlusion of the inflammatory processes—or at any rate a part of them—from communication with the excretory ducts. Thus the agglutinin concentration of the enclosed inflammatory products becomes particularly high, on account of which the agglutinins will pass over into the lymph and blood stream to a greater extent than otherwise. These observations indicate that the agglutinins in such chronic cases are formed in the local inflammatory processes. This feature is now being investigated more thoroughly.

The presence of agglutinins in sperm plasma is of diagnostic value as it indicates with a high degree of certainty that focal processes of brucellar nature are located in one or more parts of the genital system of the bull. Among the 30 bulls which showed agglutinins in the sperm plasma, 26 were found to present inflammatory changes in the vesicular gland, ampulla of the ductus deferens, epididymis or testis—either on clinical examination alone (7 bulls) or on autopsy (19 bulls). Among the 19 animals examined *post-mortem* the autopsy revealed two cases of isolated *ampullitis* that had not been diagnosed clinically. The four remaining A-reactors have not presented any clinically demonstrable changes in the genitals, and as they are still alive, it has not yet been practicable by autopsy to ascertain the site of the lesion in them. It is highly probable, however, that at any rate in two of them the lesion consisted in ampullitis.

In the present material vesiculitis was encountered in 17 bulls, ampullitis in five, epididymitis in two, and orchitis in five. Some of the bulls showed brucellar infection of several sections of the genital system, e.g., vesiculitis + ampullitis, or vesiculitis + orchitis, etc.

On several occasions it was evident that the inflammatory infection had commenced in one part of the genitals—e.g., in the ampulla ductus deferentis or in the epididymis—and subsequently had involved also other parts, e.g., the vesicular gland or the testis.

The earlier observation, that the bacterial content of the semen as a rule is very large in the acute phase of a brucellar inflammation, has been confirmed by these studies. We have now had an opportunity to observe and follow this highly important aspect in acute epididymitis as well as ampullitis and vesiculitis.

The length of the period during which the semen may contain numerous Brucella bacteria will undoubtedly vary from one case to another, but it may extend over several weeks. It is primarily in this phase that extensive spreading of the infection to females has been observed. Once the inflammation has become chronic the bacterial content will usually be low, and there is some tendency for the bacillary excretion to cease. It is very difficult, however, to say with certainty when the semen from an infected bull may be expected again to be free from Brucella bacteria, as the bacillary excretion may be periodical. Sometimes Brucella bacteria may be demonstrated in the semen for years after the initial infection.

Leaving out of consideration the cases of orchitis, in which as a rule the clinical symptoms are distinct, we found that the first sign of brucellar inflammation in one of the other genital organs mentioned very often consisted in the sudden appearance of macroscopic changes in the semen. In practice, therefore, it is of the greatest importance to pay close attention to the *appearance and consistence* of each ejaculate collected. At the least sign of any pathological admixture to the semen the use of the bull in question should be discontinued at once until the animal has been examined thoroughly.

As far as that goes, the semen from a given bull may very well have been infected for some length of time before the macroscopic changes appear. There are several things that indicate that regular employment of the *catalase test* may give some orientating information in such cases.

Spreading of brucellar infection through infected semen has been demonstrated in the following cases:

1. Bull H ("bull centre" No. 2), which was suffering from brucellar epididymitis, caused the spreading of infection to 41 herds during a period of one to two months. Blood tests were carried out according to instructions given by the Veterinary Directorate and they showed that the cows inseminated from this bull were the only reactors in 26 of the herds (as reported by B. Seit). As the primary infected reactor was sold, no spreading of the infection to other animals was observed in those cases.

In ten herds the introduction of the infection gave rise to abortion in the inseminated animals, and this brought about a secondary spreading of the infection with additional cases of abortion in the herds. Secondary spreading of the infection was observed in five herds without any abortion having been ascertained in the primarily infected animals.

XUM

2. Bull A 1802 ("bull centre" No. 4) had acute vesiculitis, and during the last nine days before this lesion was discovered it infected 20 cows in 20 hitherto brucellosis-free herds. In 17 of these herds the reactors were demonstrated 2½-4 months after the insemination, whereas two reactors were not demonstrated until about six months after the insemination. The reactors were sold as soon as possible. Still, in four of these herds the infection was spread secondarily to other animals—in one of these cases, in connection with abortion by the inseminated cow. In one herd the inseminated cow aborted 8 months later (June, 1947), without having shown positive agglutination test in January and April. All the other animals in the herd were negative by the blood test when this cow aborted. Secondary spread of the infection in the herd has not been demonstrated yet.

3. Bull A 1291 ("bull centre" No. 5) suffered from acute epididymitis. In this case the last collection of semen was three days before the affection was discovered and the bull isolated; this semen caused infection in three cows belonging to hitherto brucellosis-free herds.

4. Bull A 1908 ("bull centre" No. 10) suffered from unilateral vesiculitis. This bull appears to have caused brucellar infection in ten inseminated cows belonging to nine herds. Of this total, seven inseminations were performed in one week.

In addition, there is strong suspicion that other bulls, belonging to "centres" Nos. 1 and 3, have brought about a spread of the infection, but a more exact documentation of this through blood tests on the corresponding herds has not been practicable.

No doubt, the placing of bulls on farms where brucellosis prevails among the milk cows implies a considerable risk of infection. In particular, extensive brucellar infection has been observed among the bulls stabled in "centres" where an acute exacerbation of brucellosis has taken place—with several instances of infectious abortion. Something similar has been observed where the bulls have been stabled together with a hitherto brucellosis-free herd that has become newly infected, resulting in several cases of abortion.

From the present observations it seems obvious that during any attempt at a rationally organised, collective control of brucellosis the breeding bulls should be stabled in brucellosis-free surroundings; and this applies both to the bulls that are employed exclusively for artificial insemination as well as those used for natural mating with cows from other herds. Furthermore, these bulls should be under regular health control—in order to ensure, as far as possible, that they are free from brucellosis.

Summary

In connection with work on rational collective control of brucellosis in cattle, some cases have been encountered where the use of sperm from bulls with acute brucellar inflammatory processes in the glandula vesicularis, ampulla ductus deferentis and epididymis have conveyed the infection to a large number of inseminated cows in herds that previously were free from brucellosis.

During a period of two years a total of 394 bulls were examined: 58 showed a positive reaction for brucellosis. Among these reactors a positive agglutinin reaction in the blood was the only manifestation of the infection in 28, while 30

also showed a demonstrable amount of agglutinin in the sperm plasma, and in 15 of the latter the presence of Brucella bacteria was demonstrated either by cultivation or by inoculation of guinea-pigs.

In the bulls which showed a positive sperm plasma titre the reaction usually was of long duration, and the occurrence of agglutinins in the sperm plasma appears always to have been associated with a brucellar inflammatory focus in the testis, epididymis, ampulla ductus deferentis or glandula vesicularis. This view is supported by clinical and *post-mortem* examination of 26 of the bulls. The findings indicate that the agglutinins are formed in the focal inflammatory processes, and this finds additional support in the observation of characteristic relations between the height of the agglutinin titre in blood serum and in sperm plasma according to the different localisations of the inflammation.

An abundance of bacteria in the sperm has been found in the acute phase of vesiculitis, ampullitis and epididymitis, and spread of the infection from five bulls with such lesions has been demonstrated, while several other bulls have been highly suspected.

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COLOSTRAL TRANSMISSION OF ANTIBODY SUBSTANCES FROM MOTHER TO OFFSPRING

A Review by J. L. McGIRR

THE term colostrum signifies that peculiar glutinous emulsion secreted in greater or lesser amount by the mammary glands of all mammals in the period immediately following parturition. The Latin word, colostrum, connotes an emulsion of egg yolk with turpentine—a concoction which certainly simulates the physical properties of the immediate post-parturient mammary secretion in the bovine.

It is now well known that the ingestion of colostrum in the early hours of life is necessary to ensure the well-being of most, if not all, of our domestic animals. The essential reason for this is not so well known, though much information has been acquired since the time when it was considered that colostrum was only a laxative—Nature's provision for clearing the alimentary tract of the new-born animal of deleterious material. It is interesting to note that Howe (1921) found that, in certain species at any rate, colostrum had *no* laxative effect, but that it did not delay fæcal excretion as did milk. Unfortunately, though many of the important substances present in colostrum have been studied singly, there is, so far as the writer is aware, no comprehensive published work indicating the precise interrelationships existing between these substances (e.g., sources of essential protein N, energy metabolites, vitamins, enzymes and antibodies) and the essential, and indeed vital, nature of colostrum.

This review is concerned with the transmission of antibody substances from mother to offspring via colostrum. It seems reasonable to believe that the transmission of antibodies by this route is essentially a protective mechanism; but, on this point, little or no information is available for many of the antibodies described.

The marked differences which exist in the antibody-transmitting properties of the colostrum of different species appear to be paralleled by differences in placental construction. The significance of the placenta is almost wholly nutritional and the condition of the barrier, whether substantial, as in the epithelis-chorial placenta, or very thin, as in the hæmochorial and hæmoendothelial types, may be correlated with (1) the transmissibility of substances of various molecular weights from one circulation to the other; (2) the presence or absence of a large allantois as receptacle for fœtal excretions; (3) the relative significance of the "uterine milk"; and (4) the relative importance of the colostrum as the vehicle for substances of importance which may not have been supplied sufficiently readily by the placental path (Needham, 1942). It should be remembered that, as Mossman (1937) points out, the placental type may change during the development of the embryo, e.g., in the rabbit, which represents the supreme example of this type of change, the early placenta is of hæmo-chorial type; this changes later to hæmo-mesothelial, and later still to hæmo-endothelial. These changes are reflected in an interesting manner in experiments conducted by Rodolfo (1934). He showed that in the rabbit the ratio fœtal blood titre/maternal blood titre rose from 0.2 at 23 days to 0.8 at 30 days in the case of agglutinins to *Br. abortus*, and from 0.05 at 23 days to 1.0 at 30 days in the case of hæmolysin for sheep red blood corpuscles.

The following schematic presentation of the different types of mammalian placentæ, modified slightly from tables given by Needham (1931-1942), is reproduced for comparison with a table given later in this paper (page 355), indicating the antibody-transmitting properties of the colostrum of different animal species.

While it is true that, in general, the new-born animal in the same placental group obtains immune bodies in the same way and that the degree of relative importance of colostral or placental transmission can be correlated with the structure of the placenta, there are, as will be mentioned later, notable exceptions, e.g., the mouse and the rat belong to the hæmochorial group and yet appear to transmit the major proportion of their antibodies by the colostral rather than by the placental route.

The question of the colostral transmission of antibodies depends on at least two factors, viz.: (a) the transference of the immune bodies to the secretion of the mammary gland, and (b) their absorption, undamaged, from the alimentary tract of the nursling. Both of these factors vary according to the species involved and with the former a distinction must be drawn between colostrum and milk, while with the latter note must be taken of the time interval after birth. The methods used in the investigation of these problems have involved: (1) direct titration of colostral antibody titre either "in vitro" or by means of protective or other tests in experimental animals; and (2) titration of the serum of the young for absorption of ingested antibody either (a) after allowing the young of the immune animal to suckle normally, or (b) after allowing the new-born of the normal animal to ingest colostrum of an immune mother, or (c) after allowing the offspring of an immune mother to ingest colostrum of a normal mother (see Perla and Marmorston, 1941).

In view of the manifold differences in the phenomena under discussion in different animals, the subject matter is reviewed according to the species involved.

Classification	PLACENTA								Fate of Placenta	Macroscopic Form	Examples
	MATERNAL BARRIER				FŒTAL BARRIER						
		UTERINE MUCOUS MEMBRANE			CHORION						
	Maternal Blood	Maternal Endothelium	Maternal Connective Tissue	Maternal Epithelium	Fœtal Eathelium	Fœtal Connective Tissue	Fœtal Endothelium	Fœtal Blood			
Epithelio-Chorial	+	+	+	+	+	+	+	+	Adeciduate	Diffuse	Pig, Horse, Donkey
Syndesmo-Chorial	+	+	+	−	+	+	+	+	Transi-tional	Multiplex (Cotyle Donary)	Cow, Sheep, Goat
Endothelio-Chorial	+	+	−	−	+	+	+	+	Deciduate	Zonary	Dog, Cat, Fox
Hæmo-Chorial	+	−	−	−	+	+	+	+	Deciduate	Dis-coid: Labyrinthine: Mole, Mouse, Rat; Olliform: Man, Ape, G.-pig, (early) Rabbit	
Hæmo-Endothelium	+	−	−	−	−	−	+	+	Deciduate	Dis-coid: Labyrinthine — Rat; Olliform: G.-pig (?), (late) Rabbit	

Mouse and Rat.—More than 50 years ago Ehrlich (1892) conducted experiments which established the passage of antibodies in the mammary secretion of the mouse. He found that mice, actively immunised against ricin and abrin prior to conception, transferred this immunity to their offspring "in utero" and through their mammary glands. Young mice born of non-immunised mothers and allowed to suckle immunised lactating mothers acquired a marked immunity to abrin and ricin, while young of immune mothers which were allowed to suckle only non-immunised mice possessed a slight immunity which persisted for 4 to 10 weeks; when animals of the latter group were allowed to suckle their immune mothers the condition of immunity was very considerably prolonged. Similar findings were obtained in experiments with tetanus antitoxin. Ehrlich estimated that in 8-10 days a sufficiently high degree of immunity could be transferred by mammary secretion alone to afford adequate protection against 1,200 lethal doses of toxin. In 1897 Widal and Sicard showed that lactating mice *passively* immunised throughout lactation with a high-titre typhoid agglutinin serum transmitted these immune substances to normal sucking mice through the mammary secretion.

The transference of immunity against Trypanosome infections has been subjected to considerable study in rats. According to Kolodny (1939), this transference takes place principally by way of the colostrum and the milk; he found that the young of non-immunised rats nursing upon foster-mothers immunised against *Trypanosoma cruzi* acquired an immunity equivalent to that of the young of similar immune mothers, that there was no evidence of antibody transmission via the placental route, and that *passively* immunised mother rats transmitted antibodies to their offspring entirely through the colostrum and the milk. Protective antibodies were present not only in the colostrum but also in the milk throughout the 20-25-day lactation period and the intestines of the young allowed the absorption of antibody substances for about 20 days after birth. Similar observations have been recorded by Culbertson on the transmission of immunity against *Trypanosoma lewisi* in rats (Culbertson, 1938-1939), and against *Trypanosoma duttoni* in mice (Culbertson, 1940).

These results indicate that the mouse and rat differ from many of the hæmochorial mammals (e.g., guinea-pig and rabbit) in that the mammary secretion plays a greater part than does the placenta in the transference of protective immune bodies from mother to offspring.

Guinea-pig and Rabbit.—In the guinea-pig and rabbit, the mammary secretion does not appear to play an important role in the transference of antibodies from mother to offspring. The contrast with the finding for the mouse and rat is interestingly paralleled by the fact that the young guinea-pig at birth is well developed and feeds independently in 2-3 days, whereas the young mouse and rat are suckled for 3 weeks. That failure of intestinal absorption is not involved seems indicated by the fact that the rabbit is apparently capable of absorbing (unchanged) protein from the intestine at least up to the tenth day of life (Ganghofner and Langer).

Romer (1905) observed no transmission of diphtheria antitoxin and there is evidence that typhoid agglutinins are not transferred through the mammary secretion in guinea-pigs (Vaillard, 1896). Remlinger (1899) came to the same conclusion after a study of agglutinins in *Vibrio cholera* in rabbits and Bulloch

(1902), while finding hæmolysin in the serum of rabbits immunised with sheep red blood corpuscles and also in the serum of the newborn, found none in the colostrum or the milk. Similar findings were recorded by Ratner, Jackson and Gruehl (1927). They found that, in both guinea-pig and rabbit, the mammary secretion of the lactating female previously immunised against tetanus toxin failed to protect the young of non-immunised mothers. On the other hand, the young of immune mothers suckled by either non-immunised or immune foster-mothers were protected against 50 lethal doses of toxin. Schneider and Szathmary (1939) found that the titres of the sera of young rabbits born of mothers immunised against *S. typhi* and diphtheria toxin were practically identical with the maternal serum titres before suckling and that the ingestion of colostrum caused no change in those titres.

It is interesting to note that anaphylactic sensitivity is transferred via the placenta and that there is some evidence that placental transmission of *antigen* may occur in both guinea-pigs and rabbits (Ratner, Jackson and Gruehl, 1927-1929; Holford, 1930). There is no evidence for colostral transmission of anaphylactic sensitivity and no satisfactory evidence for the transference of true bacterial (allergic) sensitivity by either placental or colostral routes (Rich, 1944).

Dog.—Placental transmission of immune substances does not occur in the dog. Bardelli (1930) found that acquired antibodies were passed into the early mammary secretions in large amount and that these substances were readily absorbed by the young puppy for the first 10-12 days after birth. Similar results were obtained by Mason, Dalling and Gordon (1930). They found that lamb dysentry antitoxin was not transferred by the placental route and that the colostral antibody titre was higher than that of the maternal serum. The results of Schneider and Szathmary (1939), in a study of three bitches and their litters immunised with killed *S. typhi, B. Coli* and diphtheria toxoid, indicated that colostral antibody titres were about ten times higher than those of maternal sera, that traces of antibody were present in new-born young before suckling, and that the serum of the young showed high titres after the ingestion of colostrum.

Pig.—In the pig, with its epitheliochorial type of placentation, antibody transmission is by the colostral route. Nelson (1932), in a study of maternal transmission of vaccinal immunity in vaccinated sows found that 23 of 24 piglets which had been allowed to suckle were immune to vaccinia when tested 7 days after birth, while all 10 piglets which were not allowed to suckle were susceptible. It is interesting to note that vaccinia introduced intracutaneously during the first few days of life in *passively* protected piglets failed to reinforce the passive immunity (Nelson, 1934).

According to Manninger and Csontos (1934), piglets reared on the colostrum and milk of Swine Fever immune sows are more resistant to virus inoculation than are those reared on cow's milk; the piglets were infected between the 4th and 30th weeks. The results obtained by Marko (1939) indicated that piglets born of sows immunised against Swine Fever were resistant when tested by virus inoculation 26 days after birth.

Earle (1935), in a study of the influence of the ingestion of colostrum on the blood proteins of new-born foals, kids, lambs and pigs, found that the blood of all four species at birth contained little or no euglobulin and a relatively small

concentration of pseudoglobulin. Within 24 hours of the ingestion of colostrum these protein fractions showed a decided and marked rise in concentration. If no colostrum was fed, there was little or no increase in serum globulin concentration in the first 36 hours of life.

Horse.—The work of Earle (1935) cited above indicates that colostrum ingestion has a profound affect on the blood-protein picture of the new-born foal. The same worker also found that the increase of euglobulin and pseudoglobulin I was proportional to the amount of colostrum ingested. In the horse the literature available suggests that antibody transmission is by the colostral rather than by the placental route.

Ranson (1900) recorded that a foal born of a mare immunised against tetanus toxin possessed a serum antitoxin level of one-fifth that of the mare; the antitoxin content of the colostrum is not recorded nor is it mentioned whether the foal's serum was tested before it was fed colostrum. (The titre of the foal's serum suggests that colostrum was fed before the serum sample was taken for test.) Investigations conducted by Ikeda (1924) indicated that there was no placental transmission of antibody substances in the mare, that there were no immune bodies in the new-born foal before suckling, that the colostral content of antibody was high, and that the foal acquired a considerable blood titre after the ingestion of colostrum.

There is much diversity of opinion regarding the value of vaccinating mares with specific antisera and vaccines against joint-ill (see Gunning, 1947), but it seems that any transference of protective substances which may occur must be via the mammary secretion. From this viewpoint, the colostral titre and the period during which the foal is capable of absorbing antibody substances from its intestine must be of vital importance.

Sheep and Goat.—In the sheep and goat with their syndesmochorial placentation there is no transmission of antibodies " in utero "; all transmission is via the colostrum. Brieger and Ehrlich (1893) found that antitoxin produced in goats by the injection of tetanus toxin passed from the blood into the colostrum, and Famulener (1912) found that the hæmolysin produced in goats by the injection of sheep red blood corpuscles passed into the colostrum. The latter also observed that the colostral titre was higher than that of the maternal serum, that intestinal absorption of antibody only occurred during the first few days of the kids' life, and that the antibody content of the mammary secretion dropped quickly when colostrum gave way to normal milk. Similar results were recorded by Reymann (1920), who also observed that the amount of antibody acquired was proportional to the colostral globulin ingested; and by Mason, Dalling and Gordon (1930), who noted that, by the fourth day of life, the intestine of the lamb was incapable of absorbing lamb dysentry antitoxin. These workers and many others (e.g., Oxer, 1936; Schneider and Szathmary, 1939) proved that there was little or no placental transmission of antibodies, that the colostral concentration of these substances could reach concentrations considerably higher than those of maternal serum, and that the intestine of the lamb and kid was only capable of absorbing immune bodies for a day or two after birth.

As already mentioned, Earle (1935) found that at birth the euglobulin and

pseudoglobulin I fractions of the serum proteins were deficient and that colostrum ingestion increased these fractions markedly within 24 hours.

Cow.—In cattle practically all of the published evidence favours the view that there is no placental transmission of antibodies and that the colostrum is all-important in respect of this transference. There is a wealth of published information relating to bovine colostrum and an initial brief outline of its composition and of its effect on the serum proteins of the young calf may be useful.

The following table—a simplified extract of the results of work by Engel and Schlag (1924)—indicates the changes which occur in the composition of the mammary secretion in the first seven days following parturition.

CHANGES IN THE COMPOSITION OF COLOSTRUM DURING THE FIRST SEVEN DAYS AFTER CALVING

Time after calving (Hrs.)	Total Protein %	Casein %	Albumin + Globulin %	Lactose %	Fat %	Ash %	Coagulation on boiling
0	17.57	5.08	11.34	2.19	5.10	1.01	+
6	10.00	3.51	6.30	2.71	6.05	0.91	+
12	6.05	3.00	2.96	3.71	3.80	0.89	+
24	4.52	2.76	1.48	4.27	3.40	0.86	+
48	3.74	2.63	0.99	3.97	2.80	0.83	+
72	3.86	2.70	0.97	4.37	3.10	0.84	—
96	3.76	2.68	0.82	4.72	2.80	0.83	—
120	3.86	2.68	0.87	4.76	3.75	0.85	—
168	3.31	2.42	0.69	4.96	3.45	0.84	—

Colostrum thus possesses a very high albumin and globulin content, a considerable quantity of minerals (the iron content is seventeen times that of normal milk), and a low concentration of lactose. In addition, the fat of the first colostrum contains nine times as much carotene, eight times as much vitamin A, and twice as much vitamin D as does normal butter-fat (Henry and Kon, 1937), and is also rich in riboflavin (Sutton, 1946). Crowther and Raistrick (1916) showed that lactoglobulin was chemically identical with serum globulin; Wells and Osborne (1921) reached a similar conclusion after anaphylactic tests.

Howe (1921-1922) demonstrated that the blood of the calf at birth contained no euglobulin and only traces of pseudoglobulin I, and that the ingestion of colostrum by the animal at any time within two days after birth resulted in the rapid appearance of considerable quantities of these protein fractions in the blood. Howe (1924) was further able to show that the urine of the fœtus and unfed calf did not contain protein, but that the feeding of colostrum and, to a lesser extent, the feeding of maternal serum produced a proteinuria in the first three days of life. Analysis showed that the proteins appearing in calf blood and urine were euglobulin and pseudoglobulin, and their coincidental appearance after colostrum ingestion, and their absence when milk was fed, was taken to indicate colostrum as their source. The following table, derived from an electrophoretic study by Jameson and Alvarex-Tostado (1942), indicates the changes which occur in the serum proteins of the sucking calf.

As already indicated, antibody transmission from mother to offspring in the bovine species occurs more or less exclusively by the colostral route. Smith and Little (1922[a]) demonstrated that antibody to *B. Coli* was transmitted via the

colostrum and that no " in utero " transference occurred. They were further able to show that antibody absorption occurred only in the first few days of life and that 75-80 per cent. of calves deprived of colostrum failed to survive. The conclusion reached was that " the function of colostrum is essentially protective against miscellaneous bacteria which are harmless later when the protective

CHANGES IN THE SERUM PROTEINS OF THE SUCKING CALF

Age	% of Total Serum Proteins Globulin V	B	L	Albumin
New-born	—	5.9	36.8	57.3
18 hours	6.0	9.2	35.3	49.5
36 hours	41.6	7.2	21.8	29.8
3 days	49.2	5.7	17.8	27.3
5 days	48.7	6.0	10.5	34.9
2 years	43.7	6.2	9.9	40.2

functions of the calf have begun to operate and accumulate energy." Certain experiments based on the assumption that serum contains at least as much antibody as colostrum indicated the possibility of substituting serum for colostrum (Smith and Little, 1922[b]). Later evidence, however, showed that, while the feeding of serum containing *B. Coli* agglutinins protected calves against " scours," antibody was present in much higher concentration in colostrum than in blood serum (Smith and Little, 1930).

Much work on the transference of antibodies to *Br. abortus* indicates a state of affairs very similar to that obtaining with *B. Coli.* The work of Little and Orcutt (1925), Smith and Little (1923), and McAlpine and Rettger (1925) indicated that all calves were born without agglutinins to *Br. abortus* regardless of the reaction of the dams, that agglutinins passed into the colostrum in high concentrations (often much higher than that of the maternal serum), that calves were only capable of absorbing such antibodies in the first 24 hours of life, and that agglutinin-containing serum could be substituted for colostrum, provided it was fed sufficiently soon after birth. The period during which colostral-transmitted agglutinins persist in the serum of the calf is a matter of some practical significance, though, of course, it must vary within very wide limits. According to Thorp and Graham (1933), such agglutinins disappear within six months, while a recent study by McDiarmid (1946) indicates that the titre reaches a maximum within 24 hours of colostrum ingestion and then recedes as a logarithmic curve over a period varying from days to months. According to McDiarmid, the period of persistence is to a large extent proportional to the titre of the colostrum, e.g., in one calf which received colostrum with an initial titre of 1 : 10,240 the serum remained positive to the agglutination test for 18 weeks, while another which received colostrum with an initial titre of 1 : 640 was only positive for two weeks. In view of the changes which occur in the capacity of the intestine for the absorption of antibodies after the first 24 hours of life, the agglutinin titre of the calf's blood would seem to be dependent on the antibody ingested, i.e., on the colostrum titre, in the 24 hours following parturition.

Smith, Orcutt and Little (1923) found that *Br. abortus* agglutinins reached a higher titre in whey from quarters showing infection than in whey from normal

quarters. Similar results have been reported by many other workers (e.g., Niermann, 1932; Bang and Bendixen, 1932; Balozet, Cordier and Menager, 1934) and some have taken them to indicate that *Br. abortus* agglutinins are produced locally in the udder. However, it seems more likely that the agglutinins are derived from the blood, the higher concentration in affected quarters arising as a result of increased vascular permeability produced by the mastitis (F. C. Minett, 1937). The work of Jones (1926), Jones and Little (1933), and Karsten (1935) tends to support the latter hypothesis.

The relationship between blood, colostrum and milk antibody titres is illustrated by the work of Minett (1937) and of Miller and Heishman (1943) on Staphylococcal antitoxin. The latter workers found that in a group of bovines, all of which possessed appreciable serum antitoxin titres, only 17 per cent. showed antitoxin in their milk and that such milk titres were low. On the other hand, colostral antitoxin was present in amounts equivalent to, or even exceeding, that of the maternal serum. Minett's results were similar; he found the milk antitoxin titres to be 1 : 18—1 : 40 those of serum, while the colostrum titre was usually higher than that of maternal blood.

The results of work by Kerr and Robertson (1941, 1943, 1945) indicate that skin-sensitising antibodies to *Tr. fœtus* can be transferred from cow to calf via colostrum. They found that the normal agglutinin of normal bovine serum was not transferred to offspring via colostrum; that calves born of cows vaccinated with trichomonad antigen were without serum agglutinins at birth but that the ingestion of colostrum (whose titre was as high or higher than that of the maternal serum) produced a titre in the calf's serum as high as that of colostrum; that the absorption of antibody was rapid—within two hours of colostrum ingestion the titre of the calf's serum was at a level equivalent to that of the colostral whey; that by the fourth month of life the titre of the calf's serum had fallen to its normal level; and that the skin of the calf allowed to ingest antibody containing colostrum might react to specific antigen (tricin test) within 10 days. They also demonstrated that the intestine of the young calf was capable of absorbing antibody for less than 24 hours after birth and that antibody was less readily assimilated from the high-titre serum than from colostrum.

Kerr, Lamont and McGirr (1946) recently demonstrated that the colostrum of animals infected with mammalian tuberculosis regularly contained specific antibody substances—a finding confirmed and amplified by Ogg (1947). Other results were obtained indicating that passive skin sensitisation of the tuberculin type might possibly be transmitted via colostrum.

Man.—In animals such as man colostrum contains few antibodies and it apparently plays little or no significant part in the transmission of early passive immunity to the infant. The reason for the difference between the human infant and the calf is not altogether clear, although it is true that in the human being transmission of antibodies occurs through the hæmochorial placenta and that the new-born infant's blood is rich in antibodies of maternal origin. Kutter and Ratner (1923) point out some interesting contrasting facts in regard to colostrum in cattle and human beings. The cow's udder at the time of parturition is filled with 9 kgs. of colostrum, of which the calf ingests 0.9 kg. at its first feed. In women, colostrum does not appear for at least 12 hours after parturition, and the

amount secreted is about 5 ml. in the first four hours and about 90 ml. in the first 48 hours after birth. There is, therefore, a considerable proportional difference in the quantity secreted in the cow and in man.

The precise role of colostrum in man is not established, though it is true that the vitamin content is relatively higher than is that of milk and that many substances potentially capable of supplementing the infant's capabilities are present, e.g., Schlack and Scharfnagel (1932) declare that, at first, salivary amylase is aided by amylase in the milk.

Lewis and Wells (1922) repeated on the human infant Howe's study of the blood of the new-born calf. They found that, in contrast to the calf, the infant had at birth a quantity of pseudoglobulin comparable to that of the adult and that only euglobulin was lacking. The feeding of colostrum resulted in the immediate appearance of euglobulin in the infant's blood. Boyd (1922) confirmed these findings.

There is some evidence that dysentry agglutinins (Wong and Wong, 1930; Timmerman, 1931), antibodies to tubercle bacilli (Crispolti, 1934), and certain antitoxins (Neill, Gaspari, Richardson and Sugg, 1932) may be present in human colostrum, but, as already mentioned, there is no evidence to suggest that these colostrally-transmitted antibodies play any significant role.

General.—It would thus appear that, in the domestic animals, transmission of antibody substances occurs by the colostral and not by the placental route, whereas in the laboratory animals, with the notable exceptions of the rat and mouse, the converse is true. The period during which the intestine of the young animal is capable of absorbing antibody substances is of considerable importance and it is interesting to note the marked species differences which occur.

Except in larger animals, direct titration of milk has not been carried out to any extent, but where this has been done it is evident that antibodies may readily pass into the milk in the goat, cow, sheep, mare and dog. In contradistinction to colostrum, the titre of the milk for antibodies is, however, but a fraction of that of the maternal serum.

As indicated in the early part of this paper, the relationship of vitamins (and, in particular, of vitamin A) to the protective value of colostrum, and the relative significance of the antibodies and the vitamins transmitted in relation to the essential value of colostrum for the new-born animal, is not well understood. Loosli (1944), in a review article dealing with vitamins in calf health, concluded that recent studies suggested that at least part of the fairly considerable calf losses occurring under farm conditions may be due to inadequate supplies of vitamin A, ascorbic acid and niacin, while as early as 1938 Stewart and McCallum indicated the importance of vitamin A in diseases such as scours, navel-ill and joint-ill.

It may be permissible to remark that, while the permeability of the placental barrier appears, in general, to be related to the importance of colostrum for antibody transmission, the nature and molecular size of the antibodies produced in different animal species may be of considerable significance, e.g., the antibodies produced as a result of the injection of the same antigen into different animal species may show very considerable differences in molecular size.

The following table represents a synopsis of the information reviewed; it

should be remembered that the data available is, in many cases, incomplete and that there are, of necessity, considerable differences in the transmissibility of different antibodies in the same animal species.

Animal Species	Placental Type	Antibody Transmission		Period from birth during which intestinal absorption of antibodies occurs
		Placental	Colostral	
Man	Hæmochorial	+++	±	First few days
Mouse	Hæmochorial	+	+++	Probably at least 20 days
Rat	Hæmochorial	+	+++	Probably at least 20 days
Guinea-pig	Hæmochorial	+++	—	Probably at least 10 days
Rabbit	Hæmochorial Hæmoendothelial	+++	—	Probably at least 10 days
Dog	Endotheliochorial	±	+++	Probably 10-12 days
Sheep	Syndesmochorial	—	+++	Less than 4 days
Goat	Syndesmochorial	—	+++	Less than 4 days
Cow	Syndesmochorial	—	+++	24 hours
Pig	Epitheliochorial	—	+++	No data available
Horse	Epitheliochorial	—	+++	No data available

In view of the obvious importance of colostrum for the well-being of all our domestic animals, it may be permissible to enter a plea for more information of a readily available nature on the physiology of colostrum production, on the nature of the protective function of colostrum, and on the factors affecting the absorption of colostral-transmitted substances in the new-born animal.

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RUPTURE OF THE TENDO ACHILLES IN CHICKENS

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DURING investigations at the Rowett Institute in 1939 (Harriss, Johnston and Mitchell, 1947) into the influence of isolation on the incidence of fowl paralysis in chickens,* rupture of the tendo Achilles was a common pathological finding: in

* Work done for the Agricultural Research Council.

FIG. 1

Cockerel (A109) showing typical attitude when both tendons are ruptured.

FIG. 2

Comparison between a case of ruptured tendons (cockerel) and acute clinical fowl paralysis (pullet).

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all, among just over 1,000 chickens examined *post-mortem*, 38 showed ruptured tendons. This condition does not seem to have been recorded previously and appears to differ considerably from slipped-tendon (perosis), which is associated with manganese deficiency.

Symptoms.—In the living bird, rupture of the tendo Achilles is marked by acute lameness and inability to use the affected leg from the hock downwards. The body may be supported entirely on the hocks (Fig. 1). Both legs may be equally affected but frequently only one leg is involved. Many cases are clinically indistinguishable from fowl paralysis (Fig. 2), but careful palpation of the hock region (tibio-tarso-metatarsal joint or intertarsal joint, Bradley, 1938; ankle joint, Kaupp, 1918) reveals either a break in the continuity or a gross swelling of the tendo Achilles (flexor tendons). Spontaneous recovery was not observed either after rupture or even in cases with swelling alone. Affected birds may be very active. Cocks may show undiminished sexual desire.

Age and sex incidence.—In this outbreak, birds between three and 9½ months old were affected. There were five cases in birds below five months of age, 17 between five and seven months, and 16 between seven and 9½ months. No significant difference was noted in the incidence between males and females (17 males and 21 females).

Post-mortem.—*Post-mortem* examination showed the tendon ruptured across at or near the point of the hock or at the insertion of the gastrocnemius component of this tendon into the metatarsus. The rupture was frequently neat and clean but sometimes showed a jagged edge. Alternatively, the tendon, although not actually ruptured, was grossly swollen and increased to about five or six times its normal thickness and adherent to the tendon-sheath; it appeared as if badly "sprained." Only slight hæmorrhage was present and it was restricted to the immediate vicinity of the rupture.

Histology.—In the grossly thickened tendons slight round-cell infiltration is observed, but in complete rupture infiltration is absent. No infiltrations are found in the associated nerves. In some birds typical leucotic infiltrations are demonstrable in other organs or tissues, but more usually such lesions are entirely lacking.

Discussion.—Although the outbreak occurred in a flock of White Leghorns with a history of a high incidence of fowl paralysis for the previous five years, no relationship between rupture of the tendo Achilles and lymphomatosis has been demonstrated.

There appeared to be no relationship between rupture of the tendo Achilles and diet since affected birds were found in different experimental groups as well as in stock birds on a variety of diets, many of which were considered complete in all respects. No deficiency of manganese was apparent as in perosis and there were no indications that accident or injury could be blamed.

The matter could not be investigated further, but it seems worth putting on record since it has not apparently been described.

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MEDICAL (SOLUBLE VERONAL) HYPNOSIS, ANÆSTHESIA AND TOXICITY IN DOGS

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Introduction

THE barbituric acid series of powerful hypnotics were discovered by Nebelthan in 1898. These drugs are synthetised by combining derivatives of malonic acid with urea. Their present nomenclature is related to the different combinations which are then formed of barbituric acid and certain methane derivatives. The primary product is barbitone, which is di-ethyl malonyl urea, or di-ethyl barbituric acid. This drug was introduced in 1903 by Emil Fischer and von Mering under the name of veronal, which is nearly insoluble in water, but its salt, sodium barbitone (medinal) is freely soluble.

A large number of compounds of this series have been introduced into therapeutics. These differ in dosage, in duration and intensity of action, in the breadth of the therapeutic zone (fatal dose/therap. dose) and in their clinical application, e.g., as hypnotics, as premedications for general or local anæsthesia, and as anæsthetics. The differences depend on the rate of destruction of the drug in the body. Barbitone is peculiar amongst the barbiturates in that it is not broken down in the body, but is removed by excretion.

Barbitone is known to secure calmness and sleep, to suppress convulsions, and, moreover, to procure partial or even complete anæsthesia. Because medinal is not yet widely used in the veterinary practice, the present writer proceeded with this investigation; (1) to ascertain to what extent it may be used with advantage as a safe general anæsthetic or as pre-anæsthetic upon dogs; and (2) to determine also the therapeutic dose which can be used with safety in dog practice. It is essential for these purposes to determine experimentally the minimum lethal dose.

Experimental

The experimental work was carried out in the following order:—

(1) Determination of the therapeutic dose ... ... { method / results
(2) Determination of the anæsthetic dose ... ... { method / results
(3) Determination of the M.L.D. dose ... ... { method / results

(1) *Determination of the Therapeutic Dose.*

Method: To determine the minimum and maximum therapeutic doses, the following technique was adopted:—

(a) *Preparation of the animal.*

(1) The experimental dogs were ascertained to be in a normal state of health.

(2) Each dog was weighed and its weight was recorded in kilograms (kg.).

(3) The seat of injection was clipped and disinfected.

(4) An ordinary hypodermic syringe sterilised by boiling was employed for injection.

(5) Injections were carried out subcutaneously.

(b) *Preparation and injection of solution.*

(1) The drug was weighed out accurately and dissolved in tap water sterilised by boiling.

(2) The concentration used was a 20 per cent. solution.

(3) The solutions were freshly prepared and kept in sterilised bottles.

(4) The bottle containing the solution was usually kept in a water bath at about 38° C. before each injection.

(5) The solution was then slowly injected subcutaneously in gradually increasing doses, e.g., $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2 c.c., etc.

(c) *Recording the results.*

(1) The natural state of each dog was noticed before injection.

(2) After each successive injection, the effects were noticed and any abnormality in behaviour was recorded.

(3) The time at which any particular effect was seen was recorded.

(4) The series of effects, as they gradually occurred, were recorded until toxic symptoms, or even death, occurred.

(d) *Dose estimation.*

From the graded effects of the increasing doses, the following doses were determined:—

(1) The minimum therapeutic dose: the least possible dose which produced hypnosis.

(2) The maximum therapeutic dose: the maximum safe dose which produced hypnosis.

The doses and results as obtained in an experiment upon one dog are recorded in the following table. These results, moreover, were confirmed upon four more dogs.

The following conclusions may be drawn from these results:—

(1) *The minimum dose to produce hypnosis is about* 0.0375 *g. per kg. body weight and the maximum safe dose about* 0.1 *mg. per kg. body weight.* The therapeutic hypnotic dose for an average dog of about 8 kg. body weight would therefore be about 0.3-0.8 g.

(2) The body temperature gradually falls with increasing doses. The respiration becomes slowed, especially during sleep, reduced in rate and depth with increased doses, and then becomes shallow and sometimes irregular with large doses of about 0.2 g. per kg. body weight. Pulse becomes slightly accelerated with medicinal doses, and quick and imperceptible with large doses.

(2) *Determination of the Anæsthetic Dose.*

Method: The technique adopted in determining the minimum and maximum therapeutic doses was usually followed in determining the anæsthetic dose of medinal in dogs. Instead of beginning with minute doses, the procedure followed was to begin with doses in excess of the maximum therapeutic dose—namely, 0.1 g. per kg. body weight. The results as given for those obtained upon the dog

used in the experiment recorded in the following table were confirmed on several more dogs.

TABLE I.

THE MINIMUM AND MAXIMUM THERAPEUTIC DOSES OF MEDINAL FOR A DOG (4 KG. WGT.).

Actual dose of Drug g.	Dose per kg. of Drug g.	SYMPTOMS. Pulse per min.	Resp. per min.	Temp. C.	Other Symptoms
0.05	0.0125	95	21	38.4	No apparent symptoms.
0.10	0.025	95	21	38.4	No sleep but calm and stupor.
0.15	0.0375	97	21	38.4	Sleep after about 30 mins., lasting 6 hours with eyes half-open.
0.20	0.05	97	20	38.2	Ditto
0.25	0.0625	98	20	38.0	Ditto
0.30	0.075	99	18	38.0	Ditto
0.35	0.0876	99	18	37.9	Almost normal breathing during sleep.
0.40	0.1	100	17	37.8	Ditto
0.45	0.1125	102	15	37.5	Sleep after about 25 mins., lasting 8 hours, breathing notably reduced in depth and rate.
0.50	0.125	103	15	37.4	Ditto
0.55	0.1375	105	14	37.4	Sleep after about 20 mins.
0.60	1.15	106	12	37.2	Ditto
0.65	0.1625	106	12	37.2	Sleep after about 15 mins., preceded by excitation, then coma.
0.70	0.175	107	10	37.2	Ditto
0.75	0.1875	107	10	37.0	Ditto
0.80	0.2	108	10	37.0	Sleep after about 15 mins., shallow respiration which was sometimes irregular.
1.00	0.25	110	10	37.0	As above, shallow, quick, irregular respirations; pulse quick and almost imperceptible.
1.20	0.3	—	—	36.8	Deep sleep after about 15 mins., comatose, then died.

TABLE II.

THE ANÆSTHETIC DOSE OF MEDINAL FOR A DOG (6 KG. BODY WEIGHT).

Actual dose of Drug g.	Dose per kg. of Drug g.	SYMPTOMS. Pulse	Resp.	REFLEXES. Pupil	Corneal	Pedal	Skin	Remarks
—	—	85	19	—	—	—	—	Normal
0.6	0.1	86	18	Contracted	Diminished	Present	Responds	Ordinary sleep
0.72	0.12	87	17	„	„	„	„	Deep sleep
0.84	0.14	89	15	„	„	„	„	„
0.96	0.16	89	14	„	„	„	„	„
1.08	0.18	91	13	„	„	Absent	Does not respond	Anæsthetised
1.20	0.2	92	13	„	„	„	„	„
1.32	0.22	92	12	Slightly dilated	„	„	„	Comatosed
1.44	0.24	93	9	„	„	„	„	„
1.50	0.25	Imperceptible	Irregular	Dilated	„	„	„	„
1.80	0.30	„	„	„	„	„	„	Died

The following conclusions may be drawn from these results :—

(1) The pulse was gradually accelerated with increasing doses. Large doses produce an almost imperceptible, weak, irregular and quick pulse.

(2) The respiration became reduced both in depth and rate, but remained regular within the anæsthetic range of doses, but irregular, shallow and weak after exceeding that range.

(3) There were differences in the reflexes. The pedal reflex was the last to be abolished and was present, in one case, after exceeding the anæsthetic range. The corneal reflex was usually gradually diminished. The pupil was contracted during anæsthesia, but became dilated when the anæsthetic range was exceeded.

(4) *The anæsthetic dose was estimated to be* 0.18-0.2 *g. per kg. body weight* or about 1.08-1.2 g. for a dog of 6 kg. body weight.

(5) There was occasional excitement before the onset of anæsthesia. The state of stupor after this onset lasts an exceedingly long time with medinal.

(3) *Determination of the M.L.D.*

Method: To complete the investigation, it is of prime importance to determine how near the M.L.D. is to the anæsthetic dose, or, in other words, the margin of safety (= M.L.D./therapeutic dose), or the therapeutic breadth of the drug.

The experimental dogs were divided into three groups. The number in each group depended on the nature of the experiment. The technique was as described in the foregoing experiments.

Group 1: 11 dogs. Doses were injected in increasing size to ascertain approximately the dose which caused death.

Group 2: 16 dogs. Doses were injected varying slightly in size from the fatal dose, as approximately determined in group 1, so as to ascertain which dose would cause death in about 50 per cent.

Group 3: 6 dogs. The dose calculated upon group 2 was injected uniformly into all these dogs to ascertain its general effect.

TABLE III.

GROUP 1: 11 DOGS. TO ASCERTAIN APPROXIMATE LETHAL DOSE.

No. of Dog	Body weight kg.	Actual dose of Drug g.	Dose per kg. of Drug g.	Symptoms.	Result within 24 hours
1	2	0.2	0.1	Sleep after about 25 mins.	Survived
2	2	0.4	0.2	Sleep after about 20 mins.	"
3	2	0.4	0.2	Ditto	"
4	2	1.0	0.5	Ditto	Died
5	2	1.5	0.75	Excitation followed by deep sleep after 15 mins.	"
6	2	2.0	1.00	Deep sleep after 15 mins.	"
7	2	2.5	1.25	Deep sleep within 10 mins., slow respiration.	"
8	4	3.0	0.75	Sleep after 20 mins., then quickly died.	"
9	4	4.0	1.00	Sleep after about 40 mins.	"
10	5	7.5	1.50	Deep sleep after 10 mins.	"
11	5	10.0	2.00	Deep sleep after about 10 mins.	"

From the above experiment, death was found to occur with doses above 0.5 g. per kg. body weight.

The death of all dogs injected with doses of 0.75 g. per kg. body weight shows that the M.L.D. is decidedly below that dose. The death also of all dogs in this group injected with 0.5 and 0.33 g. per kg. body weight and the survival of two out

of the four dogs injected with 0.25 g. per kg. body weight denotes that 0.25 *g. per kg. body weight must be regarded provisionally as the M.L.D.*

TABLE IV.

GROUP 2: 16 DOGS. TO ASCERTAIN MORE ACCURATELY THE MINIMUM LETHAL DOSE.

No. of Dog	Body weight kg.	Actual dose of Drug g.	Dose per kg. of Drug g.	Symptoms.	Results within 24 hours
1	5.0	3.75	0.75	Deep sleep after about 15 mins.	Died
2	4.0	3.0	0.75	Excitation followed by deep sleep in 20 mins.	,,
3	4.5	3.375	0.75	Deep sleep after 15 mins.	,,
4	3.5	2.625	0.75	Ditto	,,
5	11.0	5.5	0.50	Deep sleep after about 20 mins.	,,
6	6.0	3.0	0.50	Deep sleep after about 15 mins.	,,
7	5.0	2.5	0.50	Ditto	,,
8	9.0	4.5	0.50	Deep sleep after about 20 mins.	,,
9	2.0	0.6	0.33	Sleep after about 20 mins.	,,
10	6.0	2.0	0.33	Sleep after about 25 mins.	,,
11	4.5	1.5	0.33	Ditto	,,
12	8.0	2.6	0.33	Sleep after about 20 mins.	,,
13	9.0	2.25	0.25	Ditto	Survived
14	2.5	0.625	0.25	Ditto	Died
15	10.0	2.5	0.25	Ditto	Survived
16	4.5	1.128	0.25	Ditto	Died

TABLE V.

GROUP 3: 6 DOGS. TO OBTAIN CONFIRMATION OF THE PROVISIONAL ESTIMATE OF 0.25 G. PER KG. BODY WEIGHT AS THE M.L.D. OF MEDINAL.

No. of Dog	Body weight kg.	Actual dose of Drug g.	Dose per kg. of Drug g.	Symptoms.	Results within 24 hours
1	5	1.25	0.25	Sleep after about 15 mins.	Died
2	4	1.00	0.25	Sleep after about 20 mins.	Survived
3	8	2.00	0.25	Sleep after about 15 mins.	,,
4	2	0.50	0.25	Sleep after about 20 mins.	Survived but died after 36 hours.
5	7	1.75	0.25	Ditto	Died
6	9	2.25	0.25	Ditto	,,

Survival of approximately 50 per cent. of the dogs injected with 0.25 g. per kg. body weight, indicates that this is the M.L.D. of medinal for dogs when given by subcutaneous injection.

N.B.—The most characteristic *post-mortem* findings were congestion of the lungs, brain and most of the internal organs. The acute poisoning usually ends in coma and death. The cause of death, as is noticed from the *post-mortem* findings, is mainly respiratory failure, which produces the above asphyxial symptoms.

Discussion and Summary

Barbitone, barbital or veronal, though introduced into human therapeutics in 1903, has not been used as its soluble salt (medinal) to any great extent in veterinary practice until comparatively recently.

From the experiments reported in this paper, the following general conclusions regarding medinal in dog practice may be drawn:—

1. The minimum dose to produce hypnosis is about 0.0375 g. per kg. body

weight. The maximum safe dose to produce hypnosis without appreciable toxic symptoms is about 0.1 g. per kg. body weight. The therapeutic dose falls, therefore, within the range 0.3-0.8 g. for an average dog of 8 kg. body weight by subcutaneous injection, and this produces sleep which lasts for 6-8 hours.

This statement is in approximate agreement with what is reported in such standard textbooks upon veterinary materia medica and therapeutics as those by H. J. Milks and E. Wallis Hoare, but differs from what is reported in the textbook written by G. M. Banham and W. J. Young, in which the hypnotic dose of veronal to dogs is stated to be grains 10-ʒi (0.6-4 g.) which dose range was proved by the writer to be toxic.

2. The anæsthetic dose which produces loss of consciousness, insensibility and absence or diminution of reflexes is about 0.18-0.2 g. per kg. body weight given subcutaneously. With this dose there was found occasional excitement before the onset of anæsthesia and sometimes deep sleep and stupor after anæsthesia. The anæsthetic dose of medinal for an average dog of 8 kg. body weight is therefore about 1.44-1.6 g.

From data of S. Nielson, Higgins and Spruth, 1925, and O. W. Barlow, Duncan and Glidhill, 1931 (as quoted by Sollmann), the minimum anæsthetic dose of veronal is stated to be 0.19 g. per kg. *rat* body weight by hypodermic injection. This figure resembles approximately the results obtained by the present writer, the minimum and the maximum anæsthetic doses having been found by him to be, respectively, 0.18-0.20 g. per kg. dog body weight.

3. The M.L.D. of medinal, namely, the dose which produces death in 50 per cent. of dogs, was found by the present writer to be 0.25 g. (or very slightly above 0.25 g.) per kg. *dog* body weight. A graded series of toxic symptoms were noticed before death, the most characteristic of them being coma, which was sometimes preceded by excitation, depression of respiration which is reduced in both depth and rate, fall in body temperature, accompanied with low rectal temperature, cold extremities and shivering, and sometimes mydriasis with widely dilated pupils, etc.

The statement differs somewhat from that made upon this point by some other workers. Thus Sollman has said that Nielson and others had found the minimum fatal dose of veronal is 0.31 g. per kg. *rat* body weight. Milks states that the average fatal dose of veronal was found by Eddy to be 0.30 g. per kg. *cat* body weight. Milks also states that the toxic dose of veronal is 0.5-1.0 g. per kg. dog body weight, which doses were proved to be high as compared with those obtained by the present writer.

4. Medinal is recommended for application in dog practice by the present writer in the following doses:—

(a) *Hypnotic dose:* 0.0375-0.10 g. per kg. body weight; or, for an average dog of 8 kg. body weight, 0.3-0.8 g.

(b) *Anæsthetic dose:* 0.18-0.20 g. per kg. body weight; or, for an average dog of 8 kg. body weight, 1.4-1.6 g.

The *M.L.D.* was 0.25 g. per kg. body weight, or, for an average dog of 8 kg. body weight, 2.0 g.

5. The use of medinal is also recommended as a *basal anæsthetic,* especially in major operations, after which rest and sleep are desirable. It is also recommended as *pre-anæsthetic* to ether in dogs to minimise the preliminary period of excitation and to diminish the quantity required of this latter anæsthetic. It also has indications as a laboratory anæsthetic where the animal must be kept under anæsthesia for a prolonged time in certain operations.

It is to be carefully noticed that the anæsthetic dose (0.18-0.20 g.) per kg. body weight approximates the M.L.D. (0.25 g.) per kg. and, therefore, clinical application demands care lest accidents occur.

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REVIEWS

Functional Anatomy of the Mammal (A Guide to the Dissection of the Cat and an Introduction to the Structural Relationship between the Cat and Man). By W. JAMES LEACH. 229 pages, 96 figs. New York and London: McGraw-Hill Book Co., Inc. Price: 12s. 6d.

THE author presents this book as an introduction to mammalian anatomy, more particularly for students wishing to obtain a general knowledge of the group than a special knowledge of any one species. But it is, in fact, one of the best books on the anatomy of the cat that has so far been published and as such should prove of as great a value to the veterinarian as to the biologist and medical student.

The cat is taken as a type mammal for comparison with others, particularly man, and the whole is treated on a functional basis which is not only refreshing but puts comparative anatomy in its true perspective.

After an introductory chapter on general considerations of mammalian structure, the book deals with the dissection of the cat; but throughout, both in the text and by illustration, numerous references are given to structural accommodation and homologies in man and other species. The reader must choose which of these illustrations is best suited to his line of thought, but among the most interesting given are observations on the postural requirements of the quadruped and biped and a discussion on the value of the endocrine system.

Being a functional treatise, the locomotory system gains first place, but all systems are considered in a clear and concise manner.

Space should be found for this book in many a library and laboratory shelf which has for long waited for such an edition.

C.W.O.

Technique de Dissection des Animaux Domestiques (Technique for Dissection of the Domestic Animals). By E. BOURDELLE, C. BRESSOU AND P. FLORENTIN. 247 pages, 69 figs. Paris: Lib. J.-B. Baillière et Fils. Price: 350 Fr.

THE veterinary profession is indebted to these French anatomists, who, in collaboration with their colleague Montané, have provided us with a wealth of anatomical knowledge, but in this, the latest of their publications, the emphasis is more on methods of investigation than on details of anatomical fact.

The book is presented in two sections. The first portion is designated general technique of dissection and deals with such diverse matters as selection of the subject, instruments required, methods of killing and embalming, and other general procedures. The details of the equipment required and routine employed for the establishment of an efficient Department of Anatomy will appeal only to those so concerned, but the methods of fixation of tissues for special study should be welcomed by workers in many fields.

The second portion, which is the longer, is designated special technique of dissection and gives an order of dissection of the various parts of the horse, ruminant, pig, dog and bird. How often is a good dissection, or even post-mortem, spoilt by a poor approach in the order and method of exposure of parts? It would seem that the authors intend to answer this question by giving a detailed description of their approach, and, although a fair knowledge of anatomy is assumed in the student following the directions, in general the instructions are clear and form a logical sequence. A programme is outlined for the dissection of each region of the horse and there follows suggestions for dissection of the area layer by layer. Any method of dissection must be based on this plan and is bound to invite criticism as some structures will be encountered at more than one level, but it would appear that in this work considerable pains have been taken to reduce such criticism to a minimum.

Animals other than the horse are dealt with more briefly and only in a comparative sense, and, although it must be admitted the general principles will apply, it is a pity more details are not given for the dissection of specialised areas of other animals, e.g., the ruminant stomach.

In conclusion, it can be said that this book can be recommended, at least for reference, to all engaged in the study of anatomy, whether as a temporary or more lasting study, and the authors have not in any sense detracted from their high reputation.

C.W.O.

The Bloodstock Breeders' Review. Volume XXXIV, 1945. London: The British Bloodstock Agency, Ltd., 26, Charing Cross Road. Price: £2 5s.

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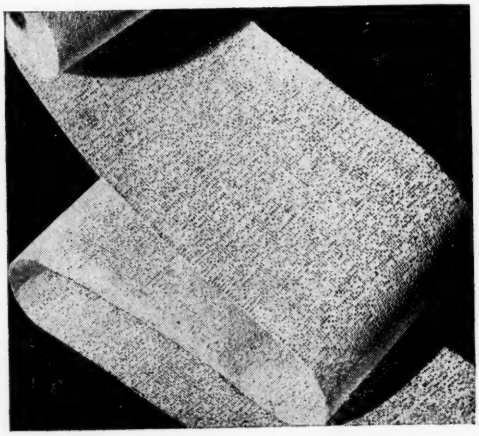

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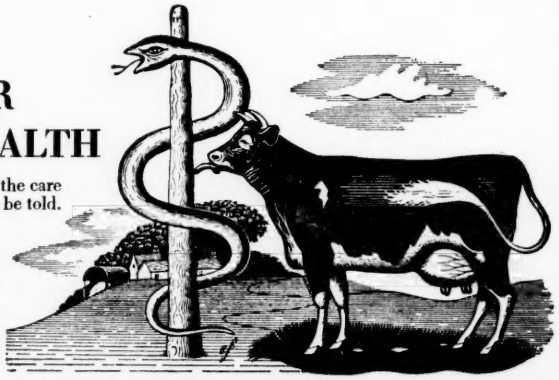

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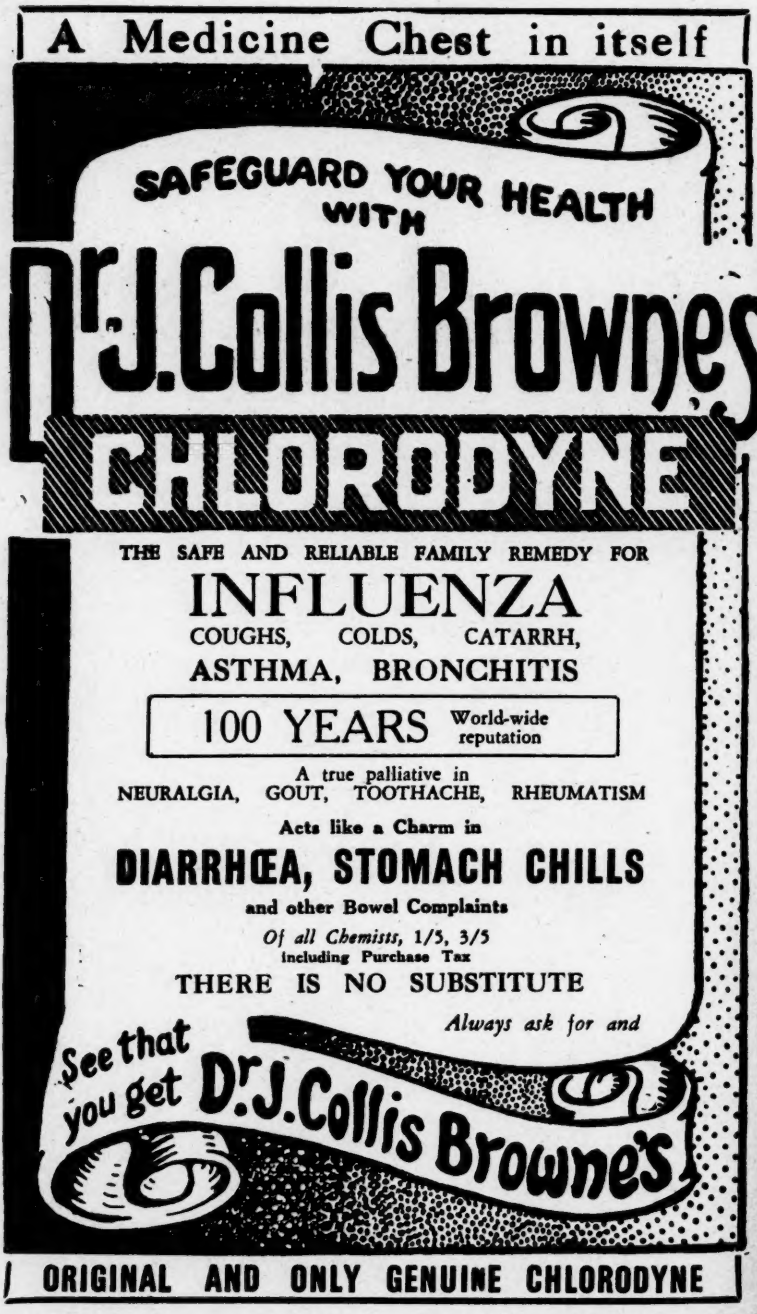
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